National Transportation Safety Board

Washington D.C. 20594

Safety Recommendation

Date: July 29, 1997

In reply refer to: A-97-46 through -52

Mr. Barry L. Valentine
Acting Administrator
Federal Aviation Administration
Washington, D. C. 20591

On December 22, 1996, at 1810 eastern standard time, a Douglas DC-8-63, N827AX, operated by ABX Air Inc. (Airborne Express) impacted mountainous terrain in the vicinity of Narrows, Virginia, while on a post-modification functional evaluation flight (FEF).[1] The three flightcrew members and three maintenance/avionics technicians on board were fatally injured.[2] The airplane was destroyed by the impact and a postcrash fire. The FEF, which originated from Piedmont Triad International Airport, Greensboro, North Carolina, was conducted on an instrument flight rules (IFR) flight plan and operated under Title 14 Code of Federal Regulations (CFR) Part 91.[3]

The National Transportation Safety Board has determined that the probable causes of this accident were the inappropriate control inputs applied by the flying pilot during a stall recovery attempt, the failure of the nonflying pilot-in-command to recognize, address, and correct these inappropriate control inputs, and the failure of ABX to establish a formal functional evaluation flight program that included adequate program guidelines, requirements

[1]Title 14 Code of Federal Regulations (CFR) Part 91.407, "Operation after maintenance, preventive maintenance, rebuilding, or alteration," requires that a FEF be conducted following maintenance "that may have appreciably changed [the airplane's] flight characteristics or substantially affected its operation in flight...." The post-modification FEF was the most extensive conducted by ABX. Air carriers routinely conduct less-exhaustive FEFs, or acceptance flights, following less extensive repairs.

[2]The three technicians were aboard to assist the flightcrew with the resolution of aircraft systems questions and problems during the FEF. A review of ABX FEF records indicated that this was a routine practice.

[3]For more detailed information, read Aircraft Accident Report—"Uncontrolled Flight into Terrain, ABX Air (Airborne Express), Douglas DC-8-63, N827AX, Narrows, Virginia, December 22, 1996" (NTSB/AAR-97/05)

and pilot training for performance of these flights. Contributing to the causes of the accident were the inoperative stick shaker stall warning system and the ABX DC-8 flight training simulator's inadequate fidelity in reproducing the airplane's stall characteristics.

Airplane Stall Warning System

The investigation revealed that the airplane's stick shaker stall warning system failed to activate during the accident sequence at the appropriate margin above the stall and during the full stall that followed. Douglas Aircraft Company records indicated that the airplane's stall warning system functioned in accordance with its design specifications when it was delivered in 1967. Preflight cockpit checks before the accident flight indicated that the airplane's stall warning system was operational; however, the preflight check of this system (using the test switch located on the flight deck overhead panel) does not test the stall warning system's wing-mounted angle of attack[4] sensor and transducer. According to records of the maintenance work performed on the airplane, a test was performed on the sensor and transducer by Triad International Maintenance Corporation (TIMCO) on December 5, 1996. This test was more extensive than the pre-flight check, but it did not include verification of the stall warning system transducer's calibration with a measured-force applicator or a functional check of the lift computer. Because stick shaker components found at the accident site were destroyed, the recovered components provided no evidence about the system's status and function. Consequently, the Safety Board was unable to identify the failure mode of the stick shaker system.

Although it did not hamper the initial identification of the stall, the absence of a stick shaker warning may have been confusing for the flightcrew. Their training and experience would have made them expect a stick shaker cue during the period that the airplane was in a stalled condition. They were trained to respond to the stick shaker by adding power and reducing control column back pressure until the stick shaker ceased.

During the first moments of the recovery attempt, an operative stick shaker would have provided the flightcrew with cues about the ineffectiveness of the pilot flying's (PF's) recovery efforts which could have alerted the pilots that the angle of attack needed to be further reduced. Similarly, if the flightcrew had received the expected cues from the stick shaker as the airplane subsequently was flown farther into the stall, the PF may have responded with more aggressive stall recovery actions, and the pilot not flying (PNF) would have received a stronger signal to intervene.

It is even possible that, in the absence of the stick shaker warning, the flightcrew may have gradually lost the perception that the airplane was stalled (especially in the latter stages of

[4]Angle of attack is the angle of the airplane wing to the relative wind. The stick shaker does not provide information about the degree to which the angle of attack exceeds a critical level, only that it has. However, knowledge that the angle of attack has approached or exceeded the level necessary for the wings to create lift effectively is important. In the absence of a stick shaker, the angle of attack can only be estimated indirectly by such cues as airplane handling characteristics, buffet or the relationship between pitch attitude, airspeed and G-loading.

the accident sequence when the airplane was descending in an accelerated stall condition at high airspeed and positive G load) and may have been attempting to perform a high airspeed, nose-low unusual attitude recovery. The unusual attitude recovery procedure calls for engine thrust to be reduced to idle and primary attention to be focused on leveling the wings; flight data recorder (FDR) engine thrust parameters and the flightcrew's statements about lateral control recorded by the cockpit voice recorder were consistent with this procedure. The Safety Board concludes that the inoperative stick shaker system contributed to the accident by failing to reinforce to the flightcrew the indications that the airplane was in a full stall during the recovery attempt. Further, based on the circumstances of this accident, the Board is concerned that existing air carrier maintenance programs may not ensure that stall warning systems are adequately checked during scheduled maintenance. Therefore, the Safety Board believes that the Federal Aviation Administration (FAA) should require Douglas Aircraft Company to review and amend the stall warning test procedures in the DC-8 maintenance manual and maintenance planning document to include regular calibration and functional checks of the complete stall warning system.

Flight Simulator Training/Stall Recovery Procedures

The Safety Board's evaluation of the ABX DC-8 simulator indicated that it did not reproduce the stall characteristics of the DC-8 with fidelity. For example, when slowed to below the airspeed of stick shaker activation, the simulator developed a stable, nose-high, wings-level descent, with no tendency to pitch down in a stall break (abrupt nose-down pitch or roll). In contrast, according to Douglas and ABX manuals and the FDR data from the accident flight, the actual DC-8 airplane's stall characteristics include a pronounced stall break. Further, after slowing well below stall speed, the simulator entered a mode in which the aerodynamic buffet stopped and the airspeed did not continue to decrease.

The simulator's benign flight characteristics when flown fully into the stall provided the flightcrew with a misleading expectation of the handling characteristics of the actual airplane. The PF's initial target pitch attitudes during the attempted stall recovery (from 10 degrees to 14 degrees) may have resulted in a successful recovery during his practice and teaching in the simulator. Further, because their experience with stalls in the DC-8 was obtained in a simulator without a stall break, the PF and PNF could not practice the nose-down control inputs required to recover a stalled airplane that is pitching down or at a nose-low attitude. Moreover, because the PF and PNF were exposed during extensive simulator experience to what they presumed was the stall behavior of the DC-8, the stall break that occurred in the airplane most likely surprised them. The Safety Board concludes that the flightcrew's exposure to a low fidelity reproduction of the DC-8's stall characteristics in the ABX DC-8 flight training simulator was a factor in the PF holding aft (stall-inducing) control column inputs when the airplane began to pitch down and roll, which contributed to the accident.

The Safety Board has previously expressed concerns about the inadequate fidelity of air carrier pilot training simulators and their deficiencies in reproducing handling characteristics of an airplane during specific maneuvers.[5] The FAA does not require air carrier flightcrews, for example, to be trained in full or deep stall maneuvers, and simulators are not required to be programmed to provide fidelity farther into the stall than the initial buffet or stick shaker.[6] Consistent with FAA requirements, simulator manufacturers do not routinely obtain accurate data about airplane stall characteristics from airplane manufacturers.[7]

However, the Safety Board is aware that for many airplane types (including the DC-8), data obtained from stall maneuvers performed during the certification process could be used to improve the fidelity of stall characteristics in air carrier flight simulators. Further, the stall phase of the flight envelope is one that has received increasing attention in air carrier pilot training through the advent of "advanced maneuver" or "selected event" training programs. Improved simulator fidelity may therefore benefit all pilots and passengers. The Safety Board believes that the FAA should evaluate the data available on the stall characteristics of airplanes used in air carrier service and, if appropriate, require the manufacturers and operators of flight simulators used in air carrier pilot training to improve the fidelity of those simulators in reproducing the stall characteristics of the airplanes they represent to the maximum extent that is practical; then add training in recovery from stalls with pitch attitudes at or below the horizon to the special events training programs of air carriers.

Training in/Surveillance of Air Carrier FEF Programs

According to the FAA's principal operations inspector (POI), a revision to the FEF stall recovery procedure was agreed upon by ABX and the FAA promptly following a 1991 loss-of-control incident during an ABX DC-8 post-modification FEF. The revised FEF stall recovery procedure stressed a positive reduction of pitch attitude to rapidly decrease the angle of attack below the critical stall angle before the application of engine power. In calling for a more positive reduction of pitch attitude, the revised procedure eliminated the emphasis of the standard ABX stall recovery procedure on minimum altitude loss.

The POI stated that the revision was accepted on behalf of ABX by the pilot who was the DC-8 flight standards manager in 1991, who had also been the pilot in command of the incident flight. The POI said that the director of flight technical programs had little involvement in the DC-8 FEF program at that time.[8] The POI described the revision to the ABX FEF stall recovery procedures in a letter to an FAA inspector at the Winston-Salem Flight Standards District Office. He told Safety Board investigators that he could not recall whether

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[5]See Aircraft Accident Report—"Runway Departure During Attempted Takeoff, Tower Air flight 41, Boeing 747-136, N605FF, JFK International Airport, New York, December 20, 1995" (NTSB/AAR-96/04); and Aircraft Accident Report—"Uncontrolled Collision with Terrain, Air Transport International, Douglas DC-8-63, N782AL, Kansas City International Airport, Kansas City, Missouri, February 16, 1995" (NTSB/AAR-95/06).

[6]See FAA Advisory Circular 120-40B, "Airplane Simulator Qualification."

[7]However, regardless of the level of simulator approval, a flight training simulator is required to provide "stall buffet to, but not necessarily beyond the FAA certified stall speed, V_s."

[8]ABX records indicate that the director of flight technical programs was on extended sick leave for some periods in 1989 and 1990, and he did not log flight time at ABX between February 19, 1990, and February 14, 1991. From March 1991 to August 1992, he was extensively involved in the ABX DC-9 FEF program. He returned to DC-8 flying in August 1992, and conducted two post-modification FEFs in the DC-8 through 1994.

he had sent a copy of this letter to ABX, although he was certain that the revised procedures had been covered during meetings and simulator sessions with ABX. He stated that he believed the revised FEF stall recovery procedures to have been a permanent change.

The DC-8 flight standards manager (who held the position in 1991) told Safety Board investigators that he had immediately begun using the revised FEF stall recovery procedures after the 1991 incident. This use was confirmed in interviews with flightcrew members who had served as second-in-command and flight engineer on many of his flights. According to ABX records, the DC-8 flight standards manager performed most of the DC-8 post-modification FEFs (which involved stalls) from 1991 through 1994, while the director of flight technical programs performed a limited number during that period.

The POI recalled that at some time following the 1991 incident (he did not remember precisely when), the director of flight technical programs had voiced disagreement about the need to change the FEF stall recovery procedures. The POI said that he was not concerned about this disagreement because, at that time, the director of flight technical programs had a limited role in the DC-8 FEF program.

The director of flight technical programs also confirmed to Safety Board investigators his belief that the stall recovery procedures contained in ABX's operations manual were adequate for FEFs if performed with sufficient attention to engine spooling. He had continued to use these stall recovery procedures when he flew FEFs. After the DC-8 flight standards manager, who had adopted the revised FEF procedure, returned to line flying in 1994 and was replaced by the accident PNF, the director of flight technical programs trained the accident PNF using the original stall recovery procedure. The accident PNF, in turn, trained the accident PF.

The Safety Board notes that some provisions of the revised procedure were implemented and used during the accident flight, although the manner in which they were used confirmed that the flightcrew was attempting the original, minimum altitude loss stall recovery. For example, the flightcrew used the block altitude clearance designed to provide sufficient altitude for stall recoveries involving greater altitude loss. However, they only obtained a 2,000-foot block, rather than the 3,000-foot to 5,000-foot block specified in the revised procedure. In addition, they conducted the stall 500 feet above the bottom of the altitude block and only slightly above the clouds. Further, although both pilots received simulator training during their informal qualification as FEF pilots, ABX did not implement a simulator session prior to each FEF, which was also specified by the POI.

Despite its partial implementation of the revised procedure, the statements of the director of flight technical programs and the actions of the accident flightcrew show that ABX ultimately did not institutionalize the technique of exchanging altitude for a more rapid stall recovery, and thus failed to take advantage of the valid lessons of the 1991 DC-8 FEF loss-of-control incident. The revised FEF stall recovery procedure (temporarily adopted by the DC-8 flight standards manager) was designed to provide an immediate stall recovery and prevent the occurrence of engine compressor surges (which occurred in the 1991 loss-of-control incident and on the accident flight). In contrast, the minimum altitude loss stall recovery procedure contained in ABX's DC-8 operations manual re-instituted by the director of flight technical programs extended the airplane's operation at a critical angle of attack and added significant exposure to the distracting and destabilizing effects of engine compressor surges.

The Safety Board concludes that the accident could have been prevented if ABX had institutionalized and the flightcrew had used the revised FEF stall recovery procedure agreed upon by ABX in 1991. The Safety Board believes that the FAA should ensure that ABX explicitly incorporates the revised FEF stall recovery procedure (that was agreed upon in 1991 by ABX and the FAA), or an equivalent procedure, in its DC-8 FEF program.

The investigation revealed that ABX had no specific prohibition against conducting an FEF at night. In addition, the pilots' direct supervisor, the director of training and standards, stated that he had conducted FEFs at night and that he would have approved the operation of the accident flight at night had he been asked by the flightcrew. ABX's director of flight technical programs also stated that he had conducted several FEFs at night, although he said that he preferred to conduct the flights during the day. In contrast to this practice at ABX, procedures established by a major U.S. airplane manufacturer for the first flight[9] after a major modification stated, "If a flight cannot depart on time to be completed by nightfall, then it should be rescheduled for the next morning."

Although ABX had set weather minimums for FEF takeoffs, no weather minimums were established by ABX for maneuvers performed at higher altitudes and beyond the vicinity of an airport, such as a stall series. Further, the guidance provided by ABX to flightcrews for the performance of the clean stall maneuver specified a minimum altitude of 10,000 feet above ground level; a maximum altitude of 15,000 feet mean sea level (msl) was also specified. However, no requirements were established by ABX for ambient lighting conditions, visual references, or distance from cloud tops. (The director of flight technical programs told Safety Board investigators that he preferred the stall series not to be performed in instrument meteorological conditions.)

In contrast, manuals of two airplane manufacturers reviewed by the Safety Board limited the stall maneuver to daylight hours. The Douglas production flight minimums further specified maximum cloud tops of 5,000 feet msl, with at least 5,000 feet clearance from clouds for performance of the stall series. In addition, the Douglas manual stated that the stall series should be performed in visual meteorological conditions (VMC) with a visible natural horizon. This restriction to a stall recovery using visual references was echoed in the manuals of two of the three air carriers reviewed by the Safety Board.

Further, according to Douglas, the approved tolerance for DC-8 stick shaker activation was within 5 knots of the calculated stick shaker activation speed. Similarly, a major

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[9]Because the functional check flight on December 21, 1996, was terminated prematurely because of mechanical problems and the flight control tests (including the stall series) were not completed, the Safety Board considers the accident flight to be the continuation of the "first flight" following major modification.

manufacturer's flight evaluation profile stated that an evaluation flight should be terminated if the stick shaker has not actuated 5 knots below the computed value. Although the ABX "Flight Test Report" provided acceptable tolerances for some evaluation items, it did not provide the acceptable tolerances for the stick shaker and stall tests. The establishment of those tolerances would have helped the crew of the accident flight to identify an inoperative stick shaker and possibly preclude entry into a full stall.

The Safety Board concludes that ABX's failure to require completion of an FEF by sundown or to establish adequate limitations on ambient lighting and weather conditions led the flightcrew to attempt the stall series in the absence of a natural horizon, and contributed to the accident. Further, based on its review of the provisions of selected air carrier and manufacturer manuals, the Safety Board concludes that there is a lack of consistency across the industry in the conditions and limitations for conducting FEFs and associated approach to stall maneuvers. Consequently, the Safety Board believes that the FAA should develop an advisory circular that provides guidance to air carriers on the appropriate conditions, limitations and tolerances for the performance of FEFs and the specific maneuvers performed during these flights, including approaches to stall.

The investigation found that the flightcrew had less pilot-in-command (PIC) experience in the DC-8 and less recent flying experience than many other pilots who did not have management responsibilities. However, the Safety Board was unable to identify any link between these measures of experience and the flightcrew's performance during the accident flight. As a result of their instruction and check airman duties, both pilots were well-acquainted with ABX procedures for conducting a stall in the clean configuration. However, an analysis of the flightcrew's recent flight experience showed that the PF had no experience as a pilot on a post-modification DC-8 FEF before the first evaluation flight on December 21, 1996. Although the PNF, who was the PIC on the accident flight, had been trained to conduct post-modification DC-8 FEFs by the director of flight technical programs 2 years before the accident, he had never served as PIC on a post-modification DC-8 FEF prior to December 21. In addition, the director of flight technical programs had operated the controls during most of the maneuvers in previous evaluation flights, while the accident PNF had occupied the right seat. The clean stall maneuver was performed by ABX pilots in the airplane only during post-modification FEFs. Therefore, neither pilot involved in the accident had performed the clean stall maneuver in a DC-8 airplane before the accident flight.

The ABX director of flight technical programs developed the flight evaluation profile for the DC-8 fleet specifying the maneuvers to be performed during FEFs. The form describing this profile, however, consisted only of a list of maneuvers with space provided for entering evaluation data during the flight. Limited guidance on the performance of FEF maneuvers was included on the form or in any other ABX publication. Training for FEFs was informal and undocumented, and ABX had established no specific training or proficiency requirements for pilots conducting FEFs.

The informality of its FEF training program led ABX to fail to recognize that a post-modification FEF was a non-routine operation with special characteristics, including further entry into the stall than was provided in regular line pilot training and for which the simulator did not provide adequate fidelity. In contrast, if ABX had been required to develop a formal curriculum for training FEF procedures, the air carrier may have recognized that simulator training for FEF stall recoveries (which comprised the PF's training for FEFs) was inadequate, and that the additional training received by the PNF (which was limited to observing the director of flight technical programs performing the stall series during several FEFs), also was inadequate. Both pilots should have been given the opportunity to perform the stall in the airplane, under the supervision of a check pilot who had previous experience with the maneuver. The Safety Board concludes that the informality of the ABX FEF training program contributed to the accident by permitting the inappropriate pairing of two pilots for a FEF, neither of whom had handled the flight controls during an actual stall in the DC-8.

Beyond providing the opportunity for ABX to have better identified the training needs of its FEF pilots, a requirement for a formal training program in FEF procedures would have also facilitated the review, approval, and surveillance of the air carrier's FEF program by the FAA. This would have increased the likelihood that the deficiencies of the program would have been identified and corrected prior to the accident.

In its investigation of a February 16, 1995, DC-8 accident at Kansas City International Airport,[10] the Safety Board also found evidence of inadequate flightcrew training and qualification for a nonroutine, special operation (a three-engine ferry operation). In both the Kansas City accident and this accident, the lack of explicit procedures and formal training for conducting nonroutine operations exposed the flights to unnecessary risks. The Safety Board concludes that the occurrence of fatal accidents during two different nonroutine operations (a FEF and a three-engine ferry) by air carriers indicates a need to identify other nonroutine operations conducted by air carriers that may require additional procedural definition and training measures. Consequently, the Safety Board believes that the FAA should identify the set of operations conducted by air carriers that require special consideration, including FEFs and other nonroutine operations that have similar needs for training and operational guidance; then amend air carrier operations specifications to include appropriate guidelines and limitations for these nonroutine operations and amend Subpart N of Title 14 CFR Part 121 to require air carriers to establish appropriate flightcrew training and qualification requirements in their training manuals.

The FAA's 1991 National Aviation Safety Inspection Program (NASIP) inspection found evidence of a general failure at ABX to ensure that company manuals and other documentation of operations procedures kept pace with the company's growth. There were no requirements for the FAA to provide surveillance of the FEF program, and there was no documentation on the FEF program in the NASIP report. However, this accident has indicated that the ABX FEF program was also functioning with inadequately defined and documented

[10]NTSB/AAR-95/06. op. cit.

guidelines for conducting evaluation flights, and inadequate flightcrew training and qualification standards for FEFs. Therefore, the FEF program deficiencies were consistent with the general problems identified by the 1991 FAA inspection.

Subsequent action by ABX and the FAA to resolve these general deficiencies focused on the specific operational areas identified by the NASIP inspection. The Safety Board concludes that the deficiencies of the ABX FEF program remained latent after general organizational problems were identified by the 1991 NASIP in the other company functions. To ensure that inadequacies in the FEF program are corrected at ABX and, if necessary, at other air carriers, the Safety Board believes that the FAA should undertake an appropriate level of surveillance of the FEF programs of all air carriers, following implementation of the Board's suggested changes to FEF and other nonroutine operations.

Authority to Conduct FEFs

ABX maintenance department managers asserted that ABX was authorized to conduct the functional test flight of the airplane under the regulations of 14 CFR Part 91. The FAA POI concurred with the procedures being used by ABX. However, the Safety Board identified confusion among FAA personnel regarding whether it was appropriate to operate the flight without a letter of deviation authority under 14 CFR Part 125.3, and whether it was appropriate to have added the accident airplane to the ABX aircraft list prior to the completion of all airworthiness certification activities, including the FEF and a final conformity inspection that was to follow the FEF. TIMCO, in a letter to the Safety Board, expressed its desire for the FAA to clarify this issue.

Based on the apparent confusion within the FAA and among the air carrier operations and maintenance communities about regulatory requirements for operating a FEF, the Safety Board concludes that the currently established FAA airworthiness and operating procedural requirements for conducting FEFs on large transport aircraft provide inadequate guidance to air carrier operators, maintenance repair stations, FAA principal operations and maintenance inspectors, and other affected parties. Consequently, the Safety Board believes that the FAA should modify the operating and airworthiness regulations of Title 14 CFR or issue appropriate guidance material to clarify airworthiness and operational procedural requirements for conducting FEFs in transport-category aircraft.

Angle of Attack Instrumentation

Following a December 20, 1995, fatal accident involving an American Airlines (AAL) Boeing 757 near Buga, Colombia, the Safety Board recommended that the FAA:

> A-96-94
> Require that all transport-category aircraft present pilots with angle of attack information in a visual format, and that all air carriers train their pilots to use the information to obtain maximum possible climb performance.

AAL flight 965 struck trees and crashed into the side of a mountain in night VMC on approach to Cali, Colombia. The airplane was destroyed, and all but four of the 163 passengers and crew on board were killed. In an October 16, 1996, recommendation letter to the FAA, the Safety Board noted the following:

> Data revealed that the first officer promptly initiated a nose-up elevator input after the GPWS [ground proximity warning system] warning activated, and continued the nose-up inputs until the stick shaker activated. Next, he immediately reduced the pitch attitude until the stick shaker stopped. He then increased the pitch attitude until the stick shaker again activated, and continued to increase the pitch attitude to the stall angle of attack. Had the stick shaker activation angle been steadily maintained during the escape maneuver, the airplane may have climbed above the initial impact point. The evidence from this accident demonstrates that inadequacies in the use of the stick shaker as a primary indicator for angle of attack limited the first officer's ability to obtain the maximum climb performance possible from the airplane when it was most needed. Although the stick shaker presents effective tactile and aural indications of the angle of attack needed to achieve maximum performance of the airplane, angle of attack information should be presented in a visual and more readily interpretable format. Military aircraft have been equipped with angle of attack indicators for many years; however, these indicators are not required on civil air transport aircraft.
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> Presentation of angle of attack information can enhance pilot control of the airplane during takeoffs and climbs, and during maneuvers, such as engine-out procedures, holding, maximum range, GPWS encounters, windshear and approach and missed approach procedures. The visual presentation of angle of attack information in transport-category aircraft, combined with pilot training in using this information to achieve maximum airplane climb performance, would enhance the ability of pilots to extract maximum performance from an airplane....

In a December 31, 1996, response to the Safety Board's letter, the FAA said that it had "initiated an evaluation to assess the operational requirements for an angle of attack indicator to obtain maximum airplane climb performance. This evaluation will include implementation and training requirements, the complexity and cost of the system, and other functions as well as indicating the angle of attack for maximum rate of climb. If it is determined that angle of attack indicators are warranted, the FAA will take appropriate regulatory action." Pending the Safety Board's evaluation of the FAA's completed action, on April 11, 1997, the Safety Board classified Safety Recommendation A-96-94 "Open—Acceptable Response."

In the ABX accident, a flight deck display of angle of attack would have maintained the flightcrew's awareness of the stall condition, and it would have provided a direct indication of the pitch attitudes required for recovery throughout the attempted stall recovery sequence. The Safety Board recognizes that, in response to Safety Recommendation A-96-94, the FAA is currently evaluating the operational requirements for angle of attack instrumentation on transport-category aircraft. However, the Safety Board concludes that this accident might have been prevented if the flightcrew had been provided a clear, direct indication of the airplane's angle of attack. Therefore, the Safety Board reiterates Safety Recommendation A-96-94.

Therefore, as a result of the investigation of this accident, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Require Douglas Aircraft Company to review and amend the stall warning test procedures in the DC-8 maintenance manual and maintenance planning document to include regular calibration and functional checks of the complete stall warning system. (A-97-46)
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> Evaluate the data available on the stall characteristics of airplanes used in air carrier service and, if appropriate, require the manufacturers and operators of flight simulators used in air carrier pilot training to improve the fidelity of these simulators in reproducing the stall characteristics of the airplanes they represent to the maximum extent that is practical; then add training in recovery from stalls with pitch attitudes at or below the horizon to the special events training programs of air carriers. (A-97-47)
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> Ensure that ABX explicitly incorporates the revised functional evaluation flight stall recovery procedure (that was agreed upon in 1991 by ABX and the FAA), or an equivalent procedure, in its DC-8 functional evaluation flight program. (A-97-48)
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> Develop an advisory circular that provides guidance to air carriers on the appropriate conditions, limitations and tolerances for the performance of functional evaluation flights and the specific maneuvers performed during these flights, including approach to stalls. (A-97-49)
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> Identify the set of operations conducted by air carriers that require special consideration, including functional evaluation flights and other nonroutine operations that have similar needs for training and operational guidance; then amend air carrier operations specifications to include appropriate guidelines and limitations for these nonroutine operations and amend Subpart N of Title 14 Code of Federal Regulations Part 121 to require air carriers to establish appropriate flightcrew training and qualification requirements in their training manuals. (A-97-50)
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> Undertake an appropriate level of surveillance of the functional evaluation flight programs of all air carriers, following implementation of the Board's suggested changes to functional evaluation flight and other nonroutine operations. (A-97-51)

Modify the operating and airworthiness regulations of Title 14 Code of Federal Regulations or issue appropriate guidance material to clarify airworthiness and operational procedural requirements for conducting functional evaluation flights in transport-category aircraft. (A-97-52)

In addition, the Safety Board reiterates Safety Recommendation A-96-94 to the FAA:

Require that all transport-category aircraft present pilots with angle of attack information in a visual format, and that all air carriers train their pilots to use the information to obtain maximum possible climb performance.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Jim Hall
Chairman